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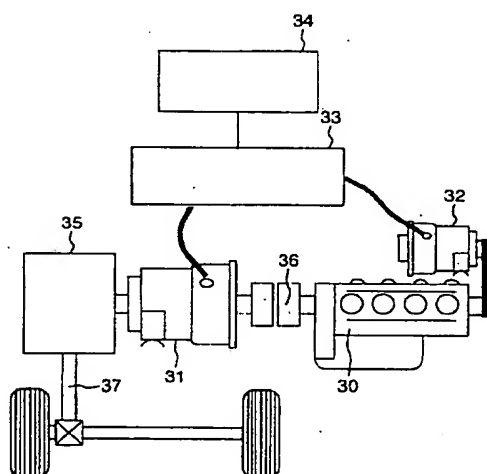
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### (54) Hybrid electric vehicle with a permanent magnetic type dynamo-electric machine

(57) The invention provides a hybrid electric vehicle employing a permanent magnet type dynamo-electric machine (31) structured such that a torque at a time of reverse rotation is greater than a maximum torque output by a dynamo-electric machine (31) when the dynamo-electric machine (31) normally rotates. Further, the present invention provides a hybrid electric vehicle in which a dynamo-electric machine (31) and an engine (30) are connected to a drive shaft (37) in series and no gear for switching between forward and backward movements is provided, wherein there is employed a permanent magnet type dynamo-electric machine (31) structured such that a torque output by the dynamo-electric machine (31) when the hybrid electric vehicle moves backward (the dynamo-electric machine (31) reverse rotates) is greater than a maximum torque output by the dynamo-electric machine (31) when the hybrid electric vehicle moves forward (the dynamo-electric machine (31) normally rotates). In the hybrid electric vehicle employing the permanent magnet type dynamo-electric machine (31) having a stator (1) having a stator iron core (2) around which a stator coil is wound, and a rotor (6) arranged in the stator (1) at a rotational gap (5) and having a plurality of permanent magnets (8) arranged and fixed within a rotor iron core (7) in a peripheral direction, a ratio between a maximum torque output by the dynamo-electric machine (31) when the dynamo-electric machine (31) normally rotates and a torque output by the dynamo-electric machine (31) when reverse rotating establishes a relation 1:1.05-1.2, whereby the

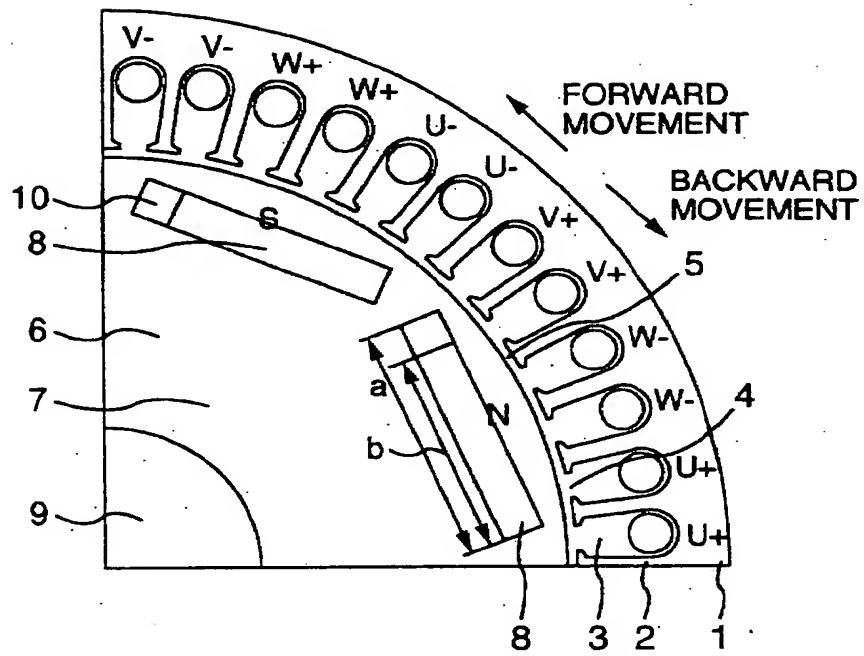
torque at the reverse rotation becomes greater.

FIG.6



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FIG.1



## Description

### BACKGROUND OF THE INVENTION

#### FIELD OF THE INVENTION

**[0001]** The present invention relates to a hybrid electric vehicle employing a permanent magnetic type dynamo-electric machine, and more particularly to a permanent magnetic type dynamo-electric machine structured such that a plurality of permanent magnets are inserted in a peripheral direction of a rotor, and a hybrid electric vehicle in which the dynamo-electric machine and an engine are connected to a drive shaft in series and no switching gear between forward and backward movements is provided.

#### DESCRIPTION OF THE PRIOR ART

**[0002]** A power property of the vehicle is 1.05 to 1.2 times larger in a speed change ratio of a forward first speed than in a speed change ratio of a backward speed. This power property is required in an electric vehicle including a hybrid vehicle in the same manner, and a greatest torque should be output in the case of backward movement.

**[0003]** In this case, in conventional, in order to intend to increase an output of a permanent magnet type dynamo-electric machine, there has been known a permanent magnet type dynamo-electric machine in which a shape of magnets in a rotor is formed in nonsymmetrical at each pole and a motor-driven vehicle employing the same. As representative embodiments, there are Japanese Patent Unexamined Publication Nos. 8-33246, 9-182331 and 9-271151.

**[0004]** The structure described in Japanese Patent Unexamined Publication Nos. 8-33246 and 9-182331 is made such that in order to provide a permanent magnet type dynamo-electric machine suitable for one way rotation, a punching hole for preventing a leakage flux is provided between the magnets, and a permanent magnet inserting hole is provided in an inner portion of an iron core in a rotor at a predetermined inclined angle with respect to a circumferential direction or a permanent magnet is arranged so as to be shifted in a direction of rotation (normal rotation), thereby increasing a total amount of magnetic flux and utilizing a reluctance torque so as to increase an output.

**[0005]** Further, the structure described in Japanese Patent Unexamined Publication No. 9-271151 is a permanent magnet type dynamo-electric machine for a motor-driven vehicle in which a magnet inserting hole is made long and a permanent magnet is arranged in a shifted manner, thereby increasing a torque. Further, as a conventional embodiment of a permanent magnet type dynamo-electric machine for an electric vehicle, there is a structure described in Japanese Patent Unexamined Publication No. 9-261901. This technique

corresponds to a structure in which the arrangement of the permanent magnet is defined by a distance from a center of the rotor in order to intend to reduce the leakage flux.

**[0006]** In this case, among the conventional arts mentioned above, at first, in the former structure in which "the permanent magnets are nonsymmetrical at each pole", it is possible to increase the torque, however, it is intended to strengthen the magnetic flux in the direction of rotation (normal rotation), so that the structure is applied to the dynamo-electric machine suitable for one way rotation. Further, the latter structure in which "the permanent magnets are nonsymmetrical at each pole" of course has the same power property at both of the forward movement (normal rotation) and the backward movement (reverse rotation). Accordingly, it is unavoidable to be the dynamo-electric machine which can output 1.05 to 1.2 times the torque inherently required at the forward movement (the same torque as that at the backward movement). Since an amount of magnetic flux is much together with outputting an unnecessary high torque, a weakening field current at a time of high speed rotation is increased so as to reduce an efficiency.

**[0007]** In particular, in a hybrid electric vehicle in which a permanent magnet type dynamo-electric machine and an engine are connected to a drive shaft in series and no gear for switching between forward and backward movements is provided, since a torque of the engine is applied at a time of forward movement, it is not necessary that the forward torque is a high torque. Further, since the dynamo-electric machine and the engine are connected to the drive shaft in series, a rotational number of the dynamo-electric machine becomes the same as that of the engine, so that a specific fuel consumption is reduced unless a high efficiency is achieved at a time of high speed rotation.

**[0008]** On the contrary, at a time of backward movement, since the gear for switching between the forward and backward movements is not provided, a high torque corresponding to 1.05 to 1.2 times the forward movement is required only by the dynamo-electric machine. In this case, at a time of backward movement, since the engine and the dynamo-electric machine are disengaged by the clutch, a high speed rotation is not performed.

#### SUMMARY OF THE INVENTION

**[0009]** The present invention is made by taking the points mentioned above into consideration, and an object of the present invention is to provide a hybrid electric vehicle employing a permanent magnet type dynamo-electric machine structured such that a torque at a time of reverse rotation is greater than a maximum torque output by a dynamo-electric machine when the dynamo-electric machine normally rotates.

**[0010]** Further, another object of the present invention is to provide a hybrid electric vehicle in which a dynamo-

electric machine and an engine are connected to a drive shaft in series and no gear for switching between forward and backward movements is provided, wherein there is employed a permanent magnet type dynamo-electric machine structured such that a torque output by the dynamo-electric machine when the hybrid electric vehicle moves backward (the dynamo-electric machine reverse rotates) is greater than a maximum torque output by the dynamo-electric machine when the hybrid electric vehicle moves forward (the dynamo-electric machine normally rotates).

[0011] In order to achieve the object mentioned above, in accordance with the present invention, there is provided a hybrid electric vehicle employing the permanent magnet type dynamo-electric machine comprising:

a stator having a stator iron core around which a stator coil is wound; and  
a rotor arranged in the stator at a rotational gap and having a plurality of permanent magnets arranged and fixed within a rotor iron core in a peripheral direction,  
wherein a ratio between a maximum torque output by the dynamo-electric machine when the dynamo-electric machine normally rotates and a torque output by the dynamo-electric machine when reverse rotating establishes a relation  $1 : 1.05-1.2$ , whereby the torque at the reverse rotation becomes greater.

[0012] Further, in the permanent magnet type dynamo-electric machine, the structure is preferably made such that a shape of the rotor at each pole is nonsymmetrical so that the ratio between the normal and reverse rotations establishes a relation  $1 : 1.05-1.2$ , whereby the torque at the reverse rotation becomes greater.

[0013] Further, in accordance with the present invention, the structure is preferably made such that a width in a rotational direction of a permanent magnet inserting hole provided within the rotor iron core is larger than a width of the permanent magnet, and a space generated by a difference of length between the both is arranged in a normal rotation side of the dynamo-electric machine.

[0014] Further, in accordance with the present invention, the structure is preferably made such that a rotor having no punching hole for preventing a leakage flux is provided, a permanent magnet inserting hole provided within the rotor iron core is provided at a predetermined inclined angle with respect to a circumferential direction so that a distance from the rotational gap is greater in the normal rotation side of the dynamo-electric machine, and the permanent magnet is inserted to the inserting hole.

[0015] Further, in accordance with the present invention, the structure is preferably made such that a cross sectional shape of the permanent magnet inserting hole

and the permanent magnet is a rectangular shape.

[0016] Further, in accordance with the present invention, the structure is preferably made such that a cross sectional shape of the permanent magnet inserting hole and the permanent magnet is an arc shape.

[0017] Further, in accordance with the present invention, the structure is preferably made such that a ratio between a width in a rotational direction of the permanent magnet inserting hole provided within the rotor iron core and a width of the permanent magnet is  $1 : 0.5-0.9$ .

[0018] Further, in accordance with the present invention, the structure is preferably made such that the permanent magnet inserting hole provided within the iron core forms a predetermined inclined angle  $\theta = 10$  to  $45$  degrees (mechanical angle) with respect to a circumferential direction.

[0019] Further, in accordance with the present invention, in order to achieve the object mentioned above, there is provided a hybrid electric vehicle having a dynamo-electric machine and an engine connected to a drive shaft in series and having no gear for switching between forward and backward movements, wherein the dynamo-electric machine is a permanent magnet type dynamo-electric machine having each of the features mentioned above.

#### BRIEF DESCRIPTION OF THE DRAWINGS

[0020]

Fig. 1 is a cross sectional view of a main portion of a permanent magnet type dynamo-electric machine in accordance with a first embodiment of the present invention;

Fig. 2 is a view showing a magnetic field analysis in the case that a relation  $b/a = 0.85$  in Fig. 1 is established;

Fig. 3 is a view showing a magnetic flux density of a rotational gap between P1 and P2 in Fig. 2;

Fig. 4 is a view showing a forward movement torque and a backward movement torque in the case of changing the value  $b/a$  in Fig. 2;

Fig. 5 is a view showing a relation between a ratio between the forward and backward movement torque and the value  $b/a$  in Fig. 4;

Fig. 6 is a view showing an embodiment of a structure of a hybrid electric vehicle employing a permanent magnet type dynamo-electric machine in accordance with the present invention;

Fig. 7 is a view showing a difference of a torque curve between the present invention and the conventional embodiment;

Fig. 8 is a view showing a magnetic field analysis in the case of applying the present invention to an embodiment having sixteen poles ( $b/a = 0.9$ );

Fig. 9 is a view showing a relation between a ratio between the forward and backward movement torque and the value  $b/a$  in the case of changing the

value  $b/a$  in Fig. 8;

Fig. 10 is a cross sectional view of a main portion of a permanent magnet type dynamo-electric machine in accordance with a second embodiment of the present invention;

Fig. 11 is a view showing a magnetic flux density of a rotational gap between P1 and P2 in Fig. 10; and

Fig. 12 is a view showing a relation between the forward and backward movement torque and the value  $b/a$  in the case of changing  $\theta$  in Fig. 10.

#### DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0021] A description will be given below of a first embodiment in which the present invention is applied to a permanent magnet type dynamo-electric machine having three phases, eight poles and forty eight slots with reference to Fig. 1 showing one pole pair. At first, in Fig. 1, a stator 1 is the same as that of the conventional structure, and is constituted by inserting and arranging U-phase stator coils U1, V-phase stator coils V1 and W-phase stator coils W1 to forty eight slots 3 formed in an annular stator iron coil 2. An opening portion 4 is formed in an inner peripheral portion of the stator iron core in correspondence to each of the slots.

[0022] On the contrary, a rotor 6 is arranged in the stator 1 at a rotational gap and is structured such as to have auxiliary protruding poles in which a plurality of permanent magnets are arranged and fixed within a rotor iron core in a peripheral direction. That is, the rotor 6 is constituted by fitting and adhering a stator iron core 7 to a rotary shaft 9 and inserting and assembling a permanent magnet 8 having a width (b) in a rotational direction, for example, made of neodymium to a rectangular punching hole having a width (a) in the rotational direction and formed in a peripheral direction of an outer peripheral portion of the rotor iron core 7 from an axial direction so that N-pole and S-pole are alternately arranged in respective receiving portions. Further, the rotor 6 is rotatably arranged within the stator 1 in a state of having a predetermined rotational gap 5 with respect to an inner peripheral portion of the stator iron core 2. In this case, the rotor iron core 7 is constituted by laminating a multiplicity of silicon steel sheets on which holes for forming the receiving portions are formed.

[0023] In this case, the width (a) in the rotational direction of the punching hole is larger than the width (b) in the rotational direction of the permanent magnet, and the space 10 generated by a difference between the lengths (a) and (b) is arranged in a direction of normal rotation, that is, a direction of forward movement of the hybrid electric vehicle. In this case, since the rotor becomes nonsymmetrical per each pole, the maximum torque becomes different in the case of normal rotation and reverse rotation, that is, the normal rotation having the space 10 has a low torque and the reverse rotation has a high torque. Further, a torque ratio between the

normal rotation and the reverse rotation is determined by a ratio between the values a and b, and since both of the cases that a relation  $b/a = 1$  is established (that is, the case that the punching hole and the magnet width are equal and the space 10 does not exist) and that a relation  $b/a = 0$  is established (that is, the case that the magnet does not exist and only the space exists, so-called reluctance torque motor) are symmetrical at each pole, the torque of the normal rotation and the torque of the reverse rotation are equal to each other. On the contrary, since the case that a relation  $b/a = 0.5$  is established (that is, the case that the width of the permanent magnet and the space 10 are equal) is most nonsymmetrical at each pole, the ratio between the torque of the normal rotation and the torque of the reverse rotation becomes maximum.

[0024] Fig. 2 shows a result of a magnetic field analysis in the case that the relation  $b/a = 0.85$  is established in a dynamo-electric machine having an output 60 kW and Fig. 3 shows a distribution of a magnetic flux density of the rotational gap between P1 and P2 in the dynamo-electric machine in Fig. 2. In accordance with Fig. 3, since the magnetic flux density in the direction of normal rotation is low and the magnetic flux density in the direction of reverse rotation is high, it is known that the reverse rotation torque is larger than the normal rotation torque.

[0025] Further, Fig. 4 shows the forward movement torque and the backward movement torque in the case of changing the value  $b/a$  in the dynamo-electric machine shown in Fig. 2 and Fig. 5 shows a relation between a ratio between the forward and backward movement torque (the backward movement torque/forward movement torque) and the value  $b/a$ .

[0026] In accordance with Fig. 4, the torque is largest in the case that the relation  $b/a = 1$  is established in both of the forward and backward movements, the torque is reduced as the value  $b/a$  becomes smaller, and the torque is smallest in the case that the relation  $b/a = 0$  is established. However, in the case that the relation  $b/a > 0.5$  is established, a reduction degree of the backward movement torque is smaller than that of the forward movement torque. In accordance with Fig. 5, it is known that the value  $b/a$  should be set to 0.5 to 0.9 in order to make the ratio between the forward and backward torque 1.05 to 1.2. If it is intended that the torque ratio is simply made 1.05 to 1.2, the value  $b/a$  0.15 to 0.5 is sufficient, however, in this case, since the torque becomes too low as is apparent from Fig. 4, the value is improper.

[0027] Here, Fig. 6 shows an embodiment of a structure of a hybrid electric vehicle corresponding to a subject of the present invention. A drive system is mainly constituted by an engine 30, a motor 31 for driving an electric vehicle, a power generator 32 driven by the engine and used for charging a battery or the like, an inverter/converter 33, a battery 34, a drive shaft 37, a speed change gear (for example, a CVT) 35, and a

clutch 36. In this case, since the drive motor 31 functions as a power generator for regeneration at a time of reducing speed, the drive motor 31 may be sometimes called as a dynamo-electric machine. In this hybrid electric vehicle, the structure is made such that the engine 30, the clutch 36, the dynamo-electric machine (driving motor) 31, the speed change gear 35 and the drive shaft 37 are connected to each other in series, and the speed change gear 35 does not have a gear for switching the front and backward movements.

**[0028]** Operations in respective travel modes are as follows:

(1) Stop time: the engine is stopped, the clutch is turned off and the motor is in an idle state (in this case, in the case that a charging amount of the battery is a little, the engine is driven so as to rotate the dynamo-electric machine as a power generator, thereby charging the battery).

(2) Low speed traveling time: the engine is stopped, the clutch is turned off and the motor is driven (in this case, in the case that the charging amount of the battery is a little, the engine is driven so as to rotate the power generator, thereby charging the battery).

(3) Middle and high speed traveling time: the engine is driven, the clutch is turned on and the motor is rotates in an accompanying manner (no output).

(4) High speed accelerating time: the engine is driven, the clutch is turned on and the motor is driven.

(5) Speed reducing time: the engine is rotated due to inertia, the clutch is turned on and the motor is regenerated (may be regenerated by the power generator).

(6) Backward moving time: the engine is stopped, the clutch is turned off and the motor is driven (in this case, in the case that the charging amount of the battery is a little, the engine is driven so as to rotate the power generator, thereby charging the battery).

**[0029]** Since the backward movement is driven only by the motor, the motor torque at the backward moving time is large. On the contrary, the low speed travel is driven only by the motor, however, in the case that the torque is insufficient, the clutch is turned on so as to drive the engine, whereby it is easy to supplement the insufficient torque.

**[0030]** Taking only the low speed side into consideration, the conventional motor having the relation  $b/a = 1$  is sufficient, however, in the hybrid electric vehicle travel modes (3) and (4), the motor is driven or rotates in an accompanying manner even at the middle and high speed rotation time. In this case, when the magnetic flux of the magnet is great, an iron loss becomes great and a weakening field current is increased since the magnetic flux amount is restricted, so that a performance is reduced.

**[0031]** In accordance with the permanent magnet type dynamo-electric machine of the present invention, the torque in the backward movement side is secured, the insufficient torque at the low speed rotation time in the forward movement side is supplemented by an assistance of the engine, and the magnetic flux amount at the middle and high speed time is reduced, whereby it is possible to improve the performance such as an efficiency at the middle and high speed time or the like, and achieve a drive system suitable for the hybrid electric vehicle.

**[0032]** Fig. 7 shows the motor torque in the case of the present invention ( $b/a = 0.9$ ) and the conventional embodiment ( $b/a = 1$ ). In accordance with this embodiment, the present invention can about 10% improve the rotational number in comparison with the conventional embodiment, and can about 1% improve the motor efficiency in the high speed side from 90% in the conventional one to 91% in the present invention.

**[0033]** In order to verify a wide use property of the present invention, the same verification is performed in the dynamo-electric machine having an output 20 kW and 16 poles. Fig. 8 shows a result of a magnetic field analysis in the case that the relation  $b/a = 0.9$  is established, and Fig. 9 shows a relation (in this case, between 0.5 and 1) between a ratio between the forward and backward movement torque (backward movement torque/forward movement torque) and the value  $b/a$  in the case of changing the value  $b/a$  in the dynamo-electric machine in Fig. 8. In accordance with Fig. 9, it is known that the value  $b/a$  is between 0.5 and 0.9 in order to make the forward and backward movement torque ratio between 1.05 and 1.2 even in the structure having 16 poles.

**[0034]** Further, in the present invention, in order to change the torque of the forward and backward movements, in addition to the method of partly forming the space as mentioned above, it is possible to achieve by the structure in which the permanent magnet inserting hole provided within the rotor iron core is provided at a predetermined inclined angle ( $\theta$ ) with respect to the circumferential direction, and the dynamo-electric machine and the front movement (normal rotation) side of the hybrid electric vehicle employing the same are provided so that a distance from the rotational gap is increased. In this case, the inclined angle ( $\theta$ ) means an inclined angle with respect to a tangent line in a center (in a rotational direction) of the permanent magnet.

**[0035]** Fig. 10 shows a result of magnetic field analysis in the case that a relation  $\theta = 10$  degrees (mechanical angle) in a dynamo-electric machine having an output 60 kW and eight poles, and Fig. 11 shows a distribution of a magnetic flux density of a rotational gap between P1 and P2 in the dynamo-electric machine in Fig. 10. As is apparent from Fig. 11, since the magnetic flux density in the direction of the normal rotation is low and the magnetic flux density in the direction of the reverse rotation is high, it is known that the reverse rotation torque

is larger than the normal rotation torque even in this case. In the case that the mechanical angle is 0 or 90 degrees, the torque ratio becomes 1 due to a symmetrical property at each pole. On the contrary, in the case of 45 degree, the torque ratio becomes greatest due to most nonsymmetrical property.

[0036] Fig. 12 shows the inclined angle ( $\theta$ ) and the ratio of the forward and backward movement torque. As is apparent from Fig. 12, when the angle  $\theta$  is set to 10 to 45 degrees, it is possible to make the ratio of the forward and backward torque between 1.05 and 1.2.

[0037] Further, in accordance with the present invention, the shape of the magnet is not limited to the rectangular shape shown in the first embodiment, but can employ various shapes such as an arc shape or the like. Further, the permanent magnet 8 may employ the other magnets than the neodymium magnet, the number of (the number of the poles of) the permanent magnets may employ the other number than eight poles and sixteen poles, and the number of the slots of the stator may employ the other number than forty eight. In this case, the magnet is not limited to the inner rotation type and can be established by an outer rotation type.

[0038] In accordance with the present invention, since the ratio between the maximum torque output by the dynamo-electric machine at the normal rotation (forward movement) time and the torque output by the dynamo-electric machine at the reverse rotation (backward movement) time is 1 : 1.05 - 1.2 and becomes greater in the backward movement, it is possible to reduce the unnecessary torque (magnetic flux) at the normal rotation (forward movement) so as to improve the efficiency at the high speed and further improve the specific fuel consumption. Further, it is possible to provide the hybrid electric vehicle with compact, light and high efficiency which can output a predetermined torque at the backward movement.

[0039] Further, since it is possible to reduce the iron loss by reducing the magnetic flux at the high speed rotation, it is not necessary to use the low iron loss steel sheet so as to reduce the cost. In this case, since it is possible to reduce the amount of the magnet in the structure using the space so as to be nonsymmetrical as the first embodiment, it is possible to reduce the cost of the magnet.

## Claims

1. A hybrid electric vehicle employing a permanent magnet type dynamo-electric machine (31) comprising:

a permanent magnet type dynamo-electric machine (31), said permanent type magnet type dynamo-electric machine (31) having a stator (1) having a stator iron core (2) around which a stator coil is wound, and a rotor (6) arranged in

said stator (1) at a rotational gap (5), having a plurality of permanent magnets (8) arranged and fixed within a rotor iron core (7) in a peripheral direction, and having auxiliary protruding poles;

said dynamo-electric machine (31) and an engine (30) being connected to a drive shaft (37) in series; and

no switching gear between forward and backward movements being provided;

wherein a ratio between a maximum torque output by said dynamo-electric machine (31) when the electric vehicle moves forward and a torque output by the dynamo-electric machine (31) when reverse moving establishes a relation 1: 1.05-1.2, whereby the torque at the reverse rotation becomes greater.

2. A hybrid electric vehicle employing a permanent magnet type dynamo-electric machine (31) as claimed in claim 1, wherein a shape in a circumferential direction of said rotor (6) at each pole is non-symmetrical so that the ratio between the normal and reverse rotations establishes a relation 1: 1.05-1.2, whereby the torque at the reverse rotation becomes greater.
3. A hybrid electric vehicle employing a permanent magnet type dynamo-electric machine (31) as claimed in claim 1, wherein a width in a rotational direction of a permanent magnet inserting hole provided within said rotor iron core (7) is larger than a width of said permanent magnet (8), and a space (10) generated by a difference of length between the both is arranged in a forward movement side of said electric vehicle.
4. A hybrid electric vehicle employing a permanent magnet type dynamo-electric machine (31) as claimed in claim 2, wherein a width in a rotational direction of a permanent magnet inserting hole provided within said rotor iron core (7) is larger than a width of said permanent magnet (8), and a space (10) generated by a difference of length between the both is arranged in a forward movement side of said electric vehicle.
5. A hybrid electric vehicle employing a permanent magnet type dynamo-electric machine (31) as claimed in claim 1, wherein a permanent magnet inserting hole provided within said rotor iron core (7) is provided at a predetermined inclined angle ( $\theta$ ) with respect to a circumferential direction so that a distance from the rotational gap (5) is greater in the normal rotation side of the dynamo-electric machine (31), and said permanent magnet (8) is inserted to said inserting hole.

6. A hybrid electric vehicle employing a permanent magnet type dynamo-electric machine (31) as claimed in claim 2, wherein a permanent magnet inserting hole provided within said rotor iron core (7) is provided at a predetermined inclined angle ( $\theta$ ) with respect to a circumferential direction so that a distance from the rotational gap (5) is greater in the normal rotation side of the dynamo-electric machine (31), and said permanent magnet (8) is inserted to said inserting hole.
7. A hybrid electric vehicle employing a permanent magnet type dynamo-electric machine (31) as claimed in claim 5, wherein said inclined angle ( $\theta$ ) is 10 to 45 degrees (mechanical angle).
8. A hybrid electric vehicle employing a permanent magnet type dynamo-electric machine (31) as claimed in claim 6, wherein said inclined angle ( $\theta$ ) is 10 to 45 degrees (mechanical angle).
9. A hybrid electric vehicle employing a permanent magnet type dynamo-electric machine (31) as claimed in claim 1, wherein a cross sectional shape in the rotational direction of said permanent magnet inserting hole and said permanent magnet (8) is a rectangular shape.
10. A hybrid electric vehicle employing a permanent magnet type dynamo-electric machine (31) as claimed in claim 2, wherein a cross sectional shape in the rotational direction of said permanent magnet inserting hole and said permanent magnet (18) is a rectangular shape.
11. A hybrid electric vehicle employing a permanent magnet type dynamo-electric machine (31) as claimed in claim 3, wherein a cross sectional shape in the rotational direction of said permanent magnet inserting hole and said permanent magnet (8) is a rectangular shape.
12. A hybrid electric vehicle employing a permanent magnet type dynamo-electric machine (31) as claimed in claim 4, wherein a cross sectional shape in the rotational direction of said permanent magnet inserting hole and said permanent magnet (8) is a rectangular shape.
13. A hybrid electric vehicle employing a permanent magnet type dynamo-electric machine (31) as claimed in claim 1, wherein a cross sectional shape in the rotational direction of said permanent magnet inserting hole and said permanent magnet (8) is an arc shape.
14. A hybrid electric vehicle employing a permanent magnet type dynamo-electric machine (31) as

claimed in claim 2, wherein a cross sectional shape in the rotational direction of said permanent magnet inserting hole and said permanent magnet (8) is an arc shape.

15. A hybrid electric vehicle employing a permanent magnet type dynamo-electric machine (31) as claimed in claim 3, wherein a cross sectional shape in the rotational direction of said permanent magnet inserting hole and said permanent magnet (8) is an arc shape.
16. A hybrid electric vehicle employing a permanent magnet type dynamo-electric machine (31) as claimed in claim 4, wherein a cross sectional shape in the rotational direction of said permanent magnet inserting hole and said permanent magnet (8) is an arc shape.
17. A hybrid electric vehicle employing a permanent magnet type dynamo-electric machine (31) as claimed in any one of claims 1-16, wherein a ratio between a width in a rotational direction of the permanent magnet inserting hole provided within said rotor iron core (7) and a width in the rotational direction of said permanent magnet is 1:0.5-0.9.



FIG.1

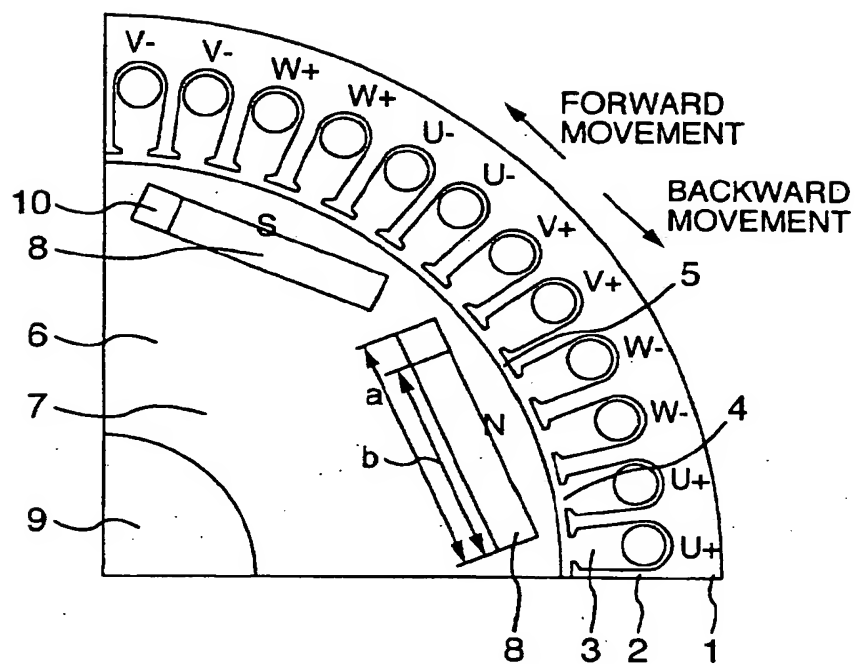


FIG.2

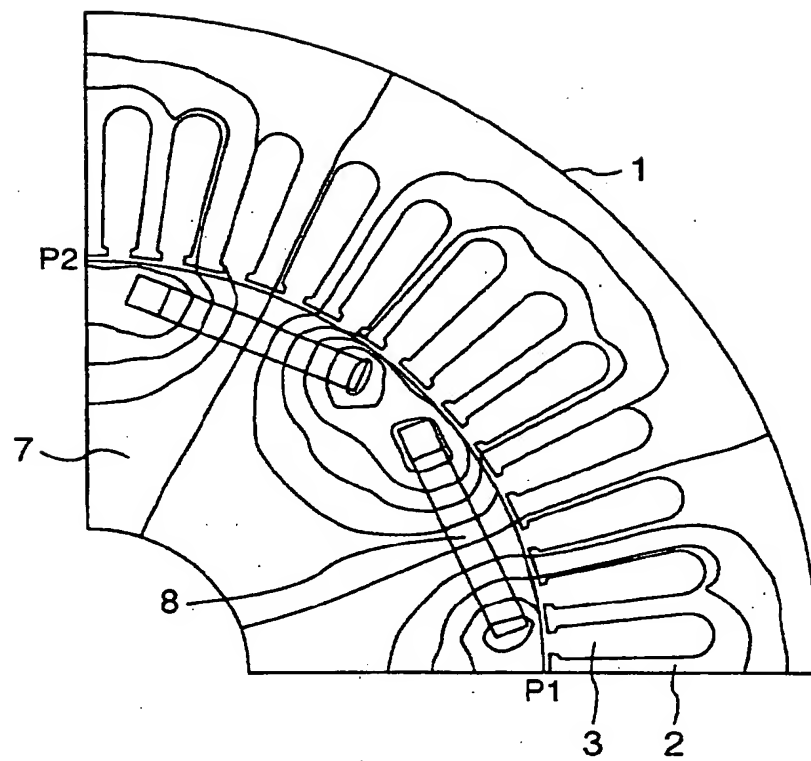


FIG.3

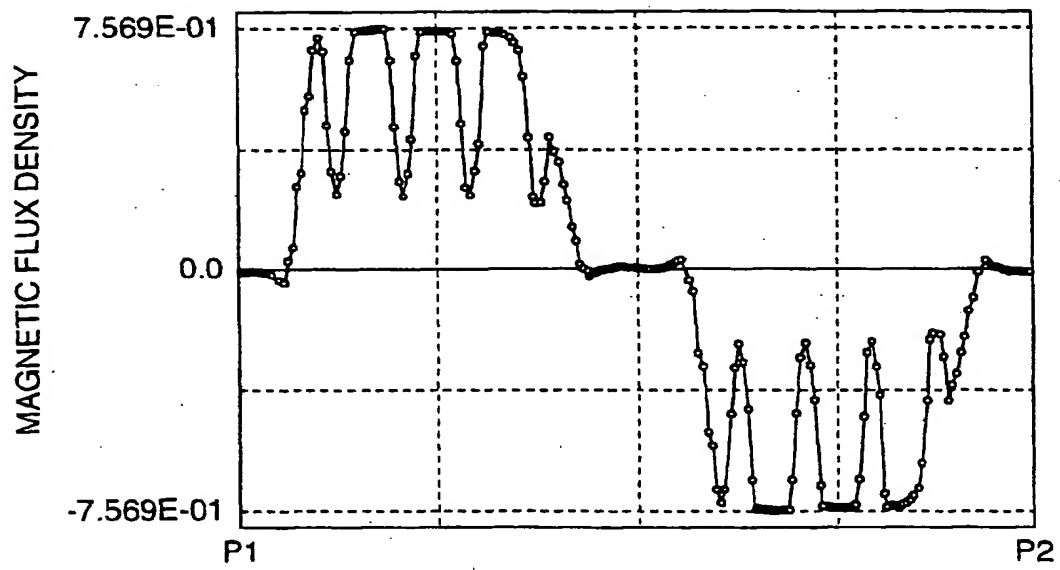


FIG.4

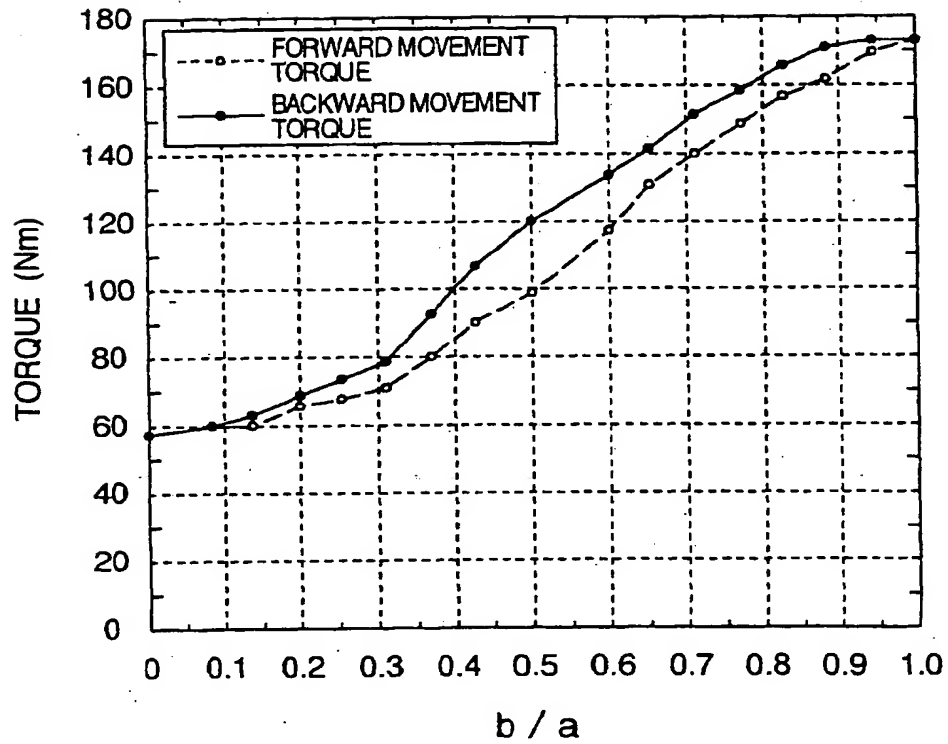


FIG.5

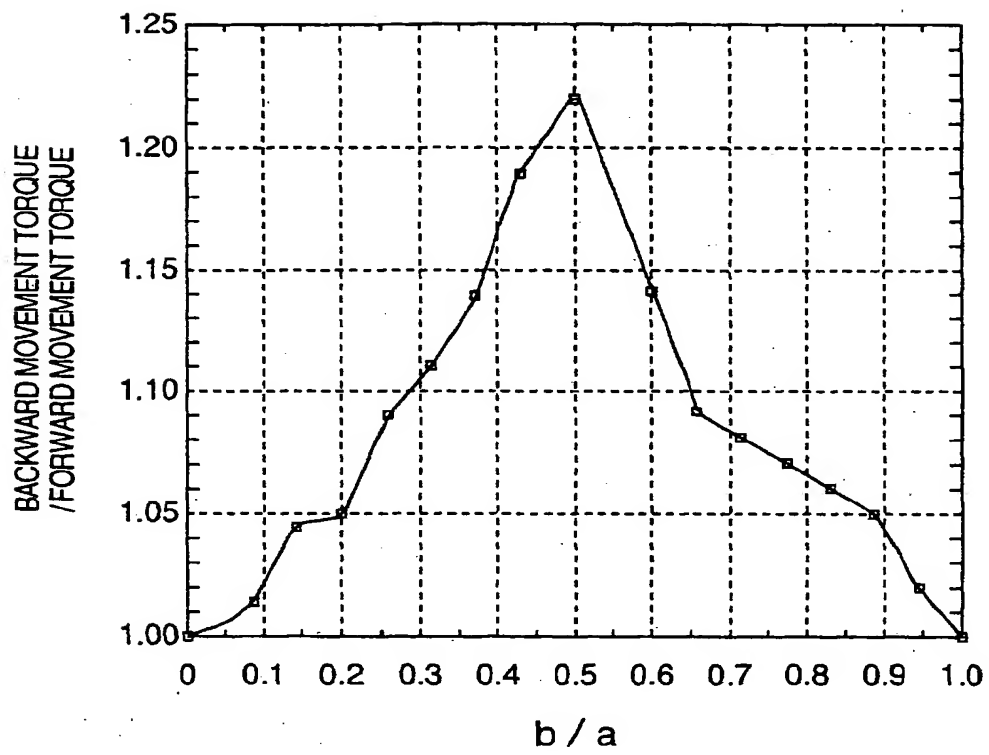


FIG.6

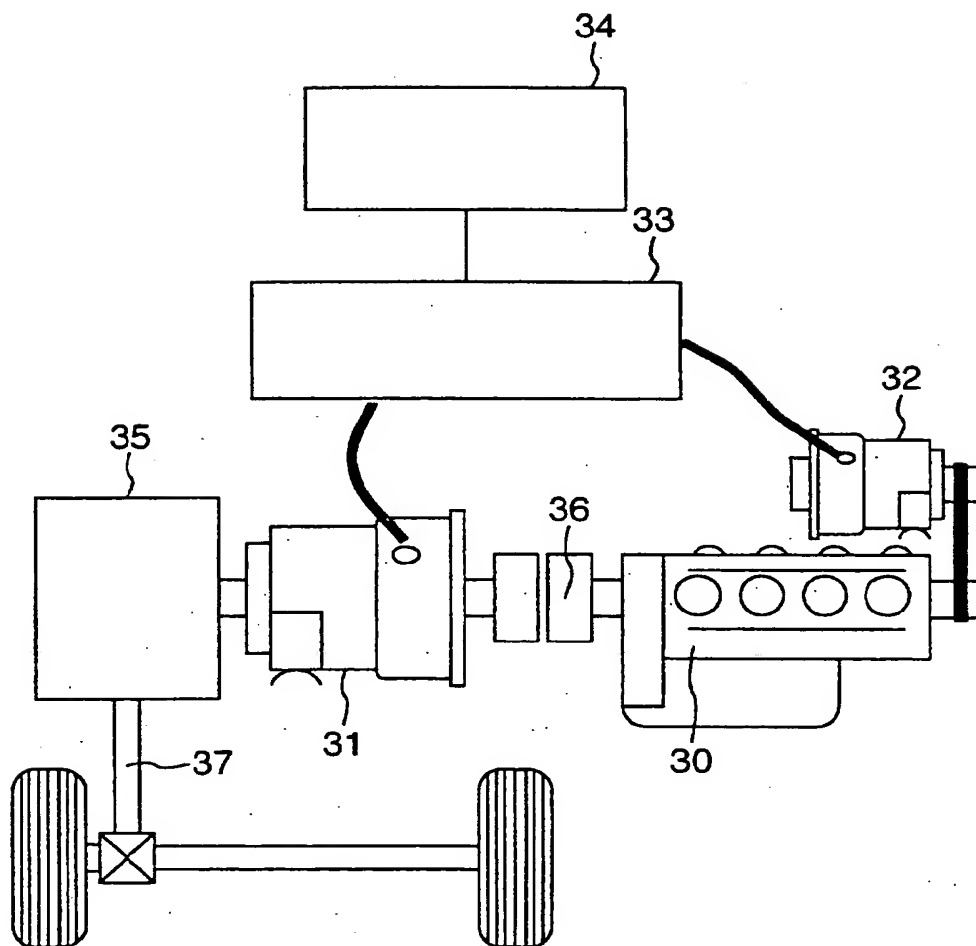


FIG.7

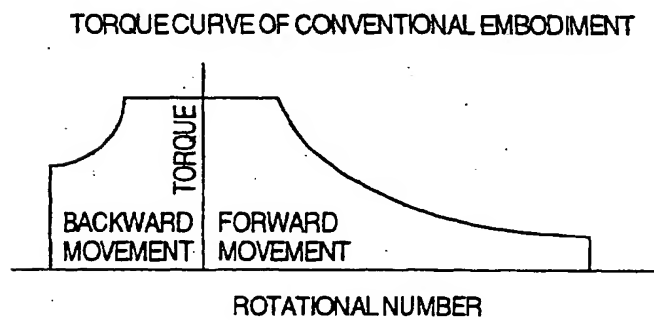
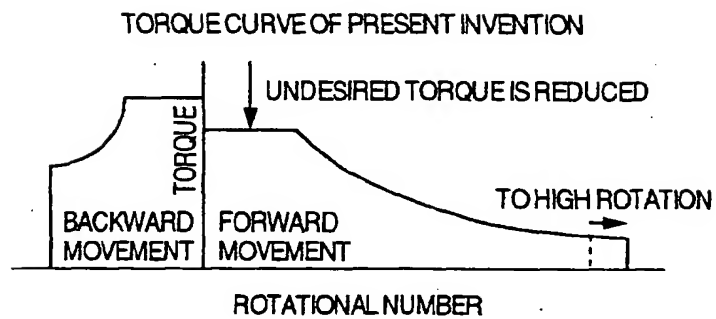


FIG.8

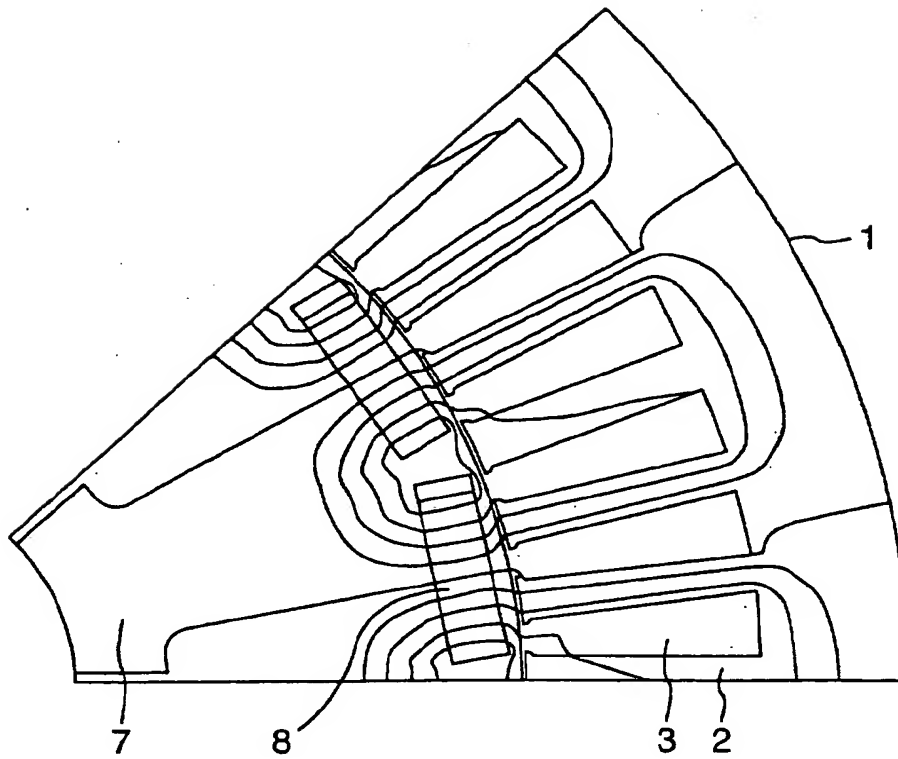




FIG.9

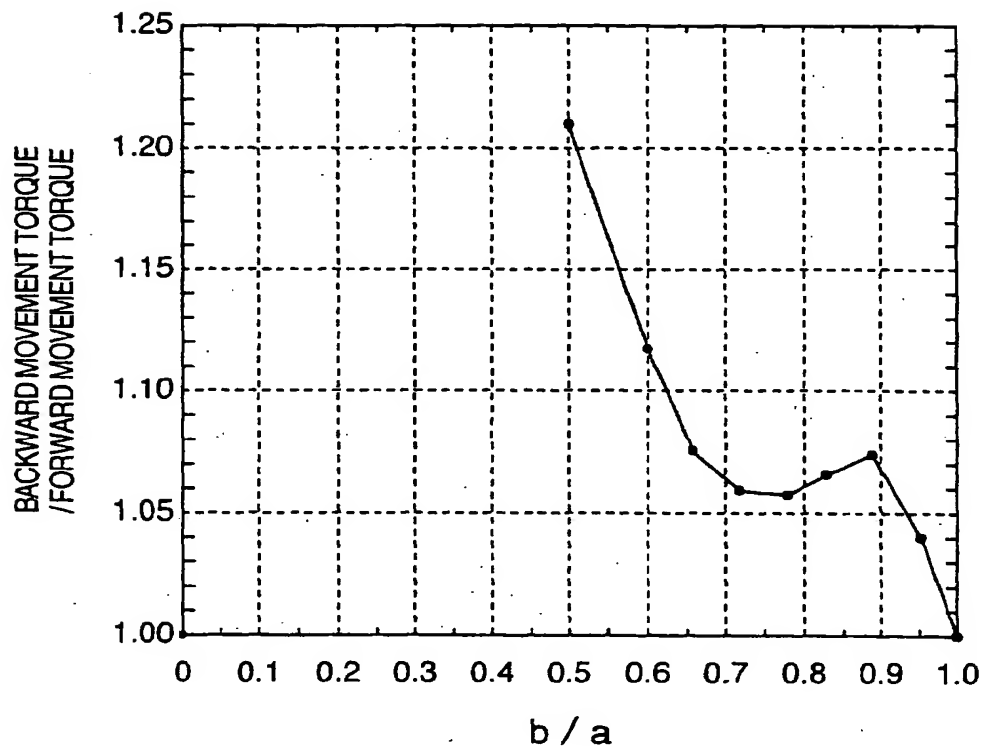


FIG.10

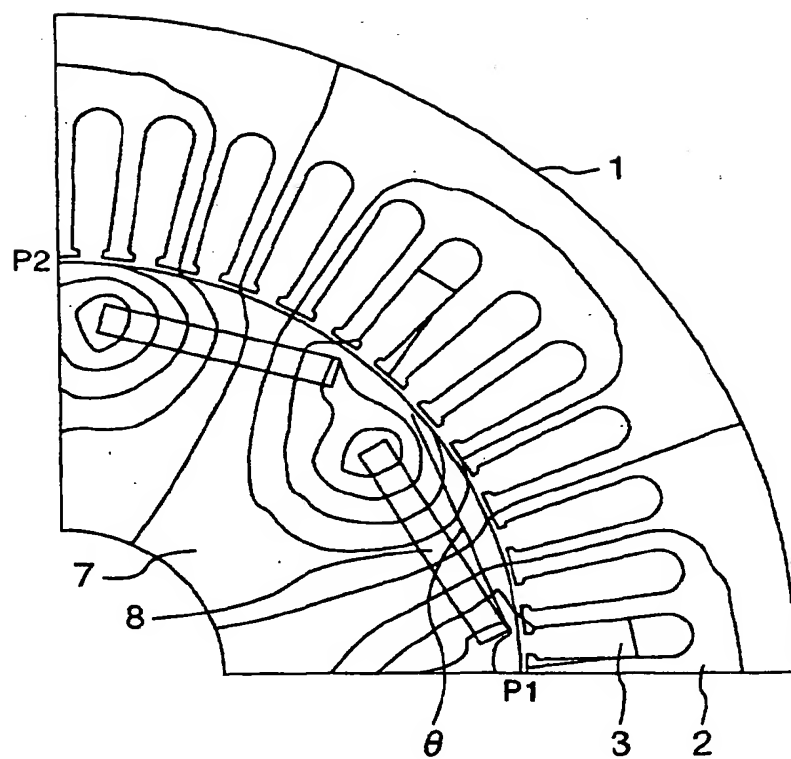


FIG.11

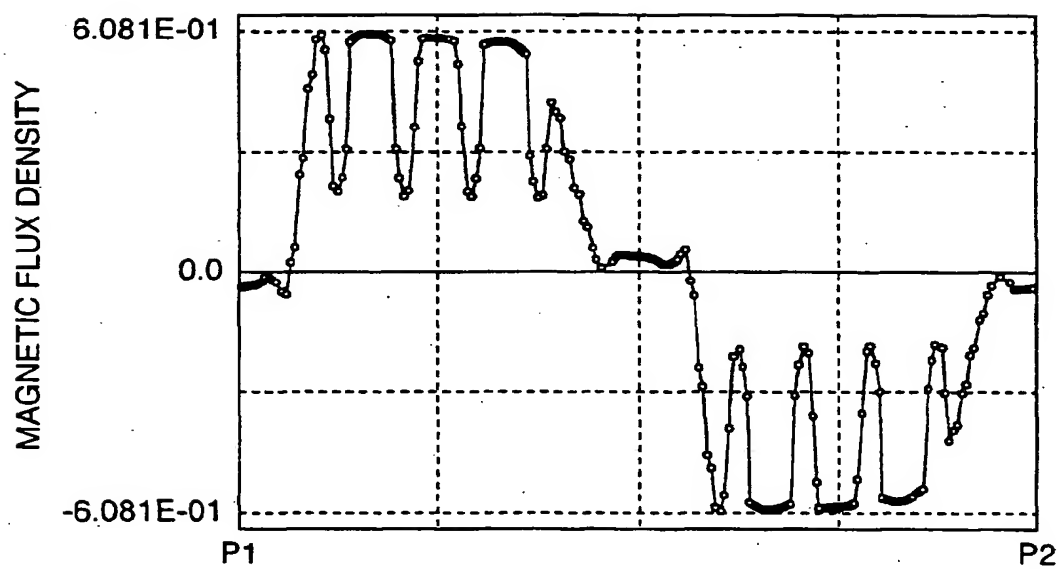
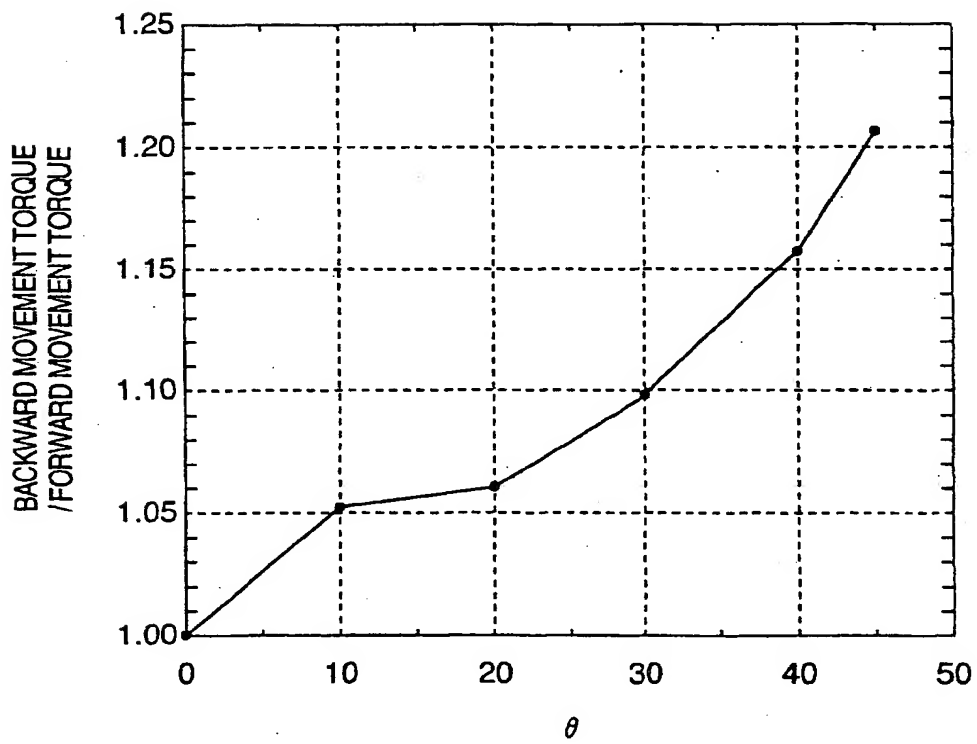
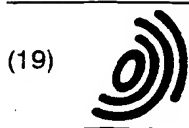


FIG.12





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(54) **Hybrid electric vehicle with a permanent magnetic type dynamo-electric machine**

(57) The invention provides a hybrid electric vehicle in which a dynamo-electric machine (31) and an engine (30) are connected to a drive shaft (37) in series and no gear for switching between forward and backward movements is provided, wherein there is employed a permanent magnet type dynamo-electric machine (31) structured such that a torque output by the dynamo-electric machine (31) when the hybrid electric vehicle moves backward is greater than a maximum torque output by the dynamo-electric machine (31) when the hybrid electric vehicle moves forward.

**FIG.6**

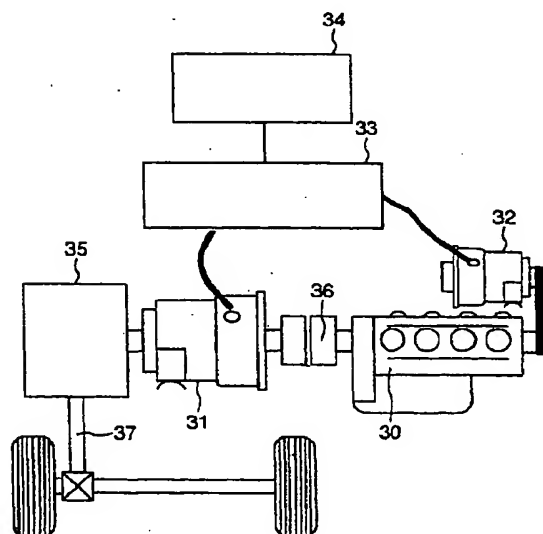
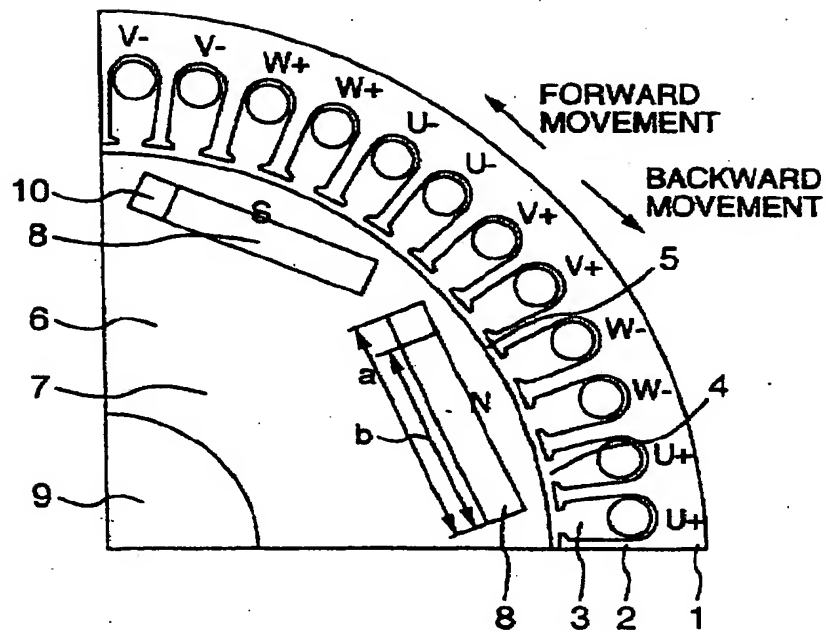


FIG.1





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## EUROPEAN SEARCH REPORT

Application Number  
EP 00 11 8187

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
Y	DE 197 47 265 A (MANNESMANN SACHS AG) 6 May 1999 (1999-05-06) * abstract * * column 3, line 57 - column 4, line 12; figure 1 *	1-17	H02K1/27 H02K21/14 H02K21/02 B60K6/04 B60L11/12
Y	US 5 811 904 A (TAJIMA ET AL.) 22 September 1998 (1998-09-22) * column 5, line 34 - column 6, line 61 * * column 7, line 31-55; figures 5-8,10 *	1-4,9-17	
D,Y	& JP 09 271151 A (HITACHI CAR ELECTRONICS KK) 14 October 1997 (1997-10-14)	1-4,9-17	
D,Y	PATENT ABSTRACTS OF JAPAN vol. 1996, no. 6, 28 June 1996 (1996-06-28) & JP 08 033246 A (YASKAWA ELECTRIC CORP), 2 February 1996 (1996-02-02) * abstract; figure 1 *	1,2,5-8	
A	US 5 343 970 A (SEVERINSKY) 6 September 1994 (1994-09-06) * abstract * * column 10, line 52-68 * * column 13, line 30-64; figures 1,4,12-14 *	1	TECHNICAL FIELDS SEARCHED (Int.Cl.7)  H02K B60K B60L
P,A	US 6 048 289 A (HATTORI ET AL.) 11 April 2000 (2000-04-11) * column 2, line 42 - column 3, line 22 * * column 7, line 61-67; figure 1 *	1	
A	& JP 11 280512 A (NISSAN MOTOR) 12 October 1999 (1999-10-12)	1	
A	DE 43 42 735 A (HÖHN, BERND-ROBERT) 22 June 1995 (1995-06-22) * abstract * * column 2, line 51-60; figures 1,2 *	1	
The present search report has been drawn up for all claims			
Place of search <b>BERLIN</b>		Date of completion of the search <b>7 August 2002</b>	Examiner <b>Beitner, M</b>
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 03/02 (704C01)



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# EUROPEAN SEARCH REPORT

Application Number  
EP 00 11 8187

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
A	DE 43 39 703 A (SCHLÖTZER, EUGEN) 24 May 1995 (1995-05-24) * abstract * * column 1, line 37-56 * * column 2, line 1-6; figure 1 * -----	1	
			TECHNICAL FIELDS SEARCHED (Int.Cl.7)
The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
BERLIN		7 August 2002	Beitner, M
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 03/82 (P04C01)



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ON EUROPEAN PATENT APPLICATION NO.**

EP 00 11 8187

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The members are as contained in the European Patent Office EDP file on  
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07-08-2002

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
DE 19747265	A	06-05-1999	DE 19747265 A1	06-05-1999
			US 6249723 B1	19-06-2001
			US 2001044682 A1	22-11-2001
US 5811904	A	22-09-1998	JP 9261901 A	03-10-1997
			JP 9271151 A	14-10-1997
			US 6188157 B1	13-02-2001
			US 2001017492 A1	30-08-2001
JP 08033246	A	02-02-1996	NONE	
US 5343970	A	06-09-1994	WO 9601193 A1	18-01-1996
US 6048289	A	11-04-2000	JP 11280512 A	12-10-1999
DE 4342735	A	22-06-1995	DE 4342735 A1	22-06-1995
DE 4339703	A	24-05-1995	DE 4339703 A1	24-05-1995

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/B2